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I. MODIS North Atlantic Test Site Characterization and Utilization

As previously reported, the MODIS North Atlantic Test Site has been established as originally proposed. The Test Site includes the New York Bight/Mid-Atlantic Bight/Gulf Stream/Sargasso Sea generally located north and east of GSFC/WFF. Characterization has been initiated by ship sampling, aircraft overflights, and historical data available from within the NASA AOL project since 1980.

This quarter the Test Site was both characterized and used as a source of new experimental airborne active-passive ocean color data in pursuit of this team member's algorithm for the detection and mapping of the phytoplankton chlorophyll accessory pigment, phycoerythrin. For the first time in the Atlantic Ocean, ship samples were taken for the purpose of providing quantitative pigment extractions to calibrate the airborne data for development of the phycoerythrin algorithm. The active (laser) airborne detection of phycoerythrin has been established since 1979 and the evidence for passive (solar) detection at 600nm was published in 1986 and 1990.

Dr. Maria Vernet of Scripps Institution of Oceanography, recognized for her work with phycoerythrin pigment, acquired surface water containing the phycoerythrin pigment. The samples were acquired during a transit of the Research Vessel Cape Henlopen from Bermuda to its home port at the Marine Science Center field laboratory of the University of Delaware in Lewes, Delaware. This use of the vessel was also done in cooperation with cruise Chief Scientist, Dr. James Ammerman of Texas A&M University. Two overflights with the NASA Airborne Oceanographic Lidar were conducted in March, 1993. While the airborne operations were aggravated by persistent partial cloud cover, the acquired airborne active passive data appear at this time to be of acceptable quality and of sufficient quantity to allow an initial evaluation of the level of phycoerythrin pigment concentration. The work schedule of Dr. Vernet has prevented the

immediate extraction of the pigment in her laboratory at Scripps. It is anticipated that the extractions will be complete by the next quarter.

Dr. Vernet also acquired filtered samples to allow further evaluation of the dissolved organic matter (DOM) within the MODIS Test Site from the Delaware Bay mouth across the shelf and slope, the Gulf Stream and into the Sargasso Sea near the island of Bermuda. The spectral absorption and fluorescence of these samples are being measured by Dr. Tony Vodacek, National Research Council post-doctoral scientist. See Section II below for a rationale for the parallel DOM effort and a summary of past work with DOM. Another flight was conducted to the northeast of GSFC/WFF in early April 1993 to characterize the MODIS Test Site during the collapse of the spring phytoplankton bloom. In addition, this flight allowed the concurrent evaluation of a new multichannel array detector manufactured by Analytical Spectral Devices, Inc. but loaned to AOL the project. Additionally, the evaluation of a sea surface temperature sensor manufactured and loaned to the project by Heimann/EG&G was conducted. The color sensor was found to lack the requisite sensitivity for ocean color spectra in a high-rate/low-integration-time mode needed to allow editing of data containing glint. The temperature sensor needs further flight and data evaluation before conclusion to purchase either is finalized.

II. Prior Efforts in the MODIS Test Site

The near-term in situ characterization of the test site was initiated on February 28, 1991 with the acquisition of surface layer grab-samples during the Surface Wave Dynamics Experiment (SWADE). Through the cooperation of Dr. Charles Flagg arrangements were made to collect 20 samples along an in-bound track line from the Gulf Stream to the mouth of the Delaware Bay. The samples were filtered (0.45 um) to remove scatterers and absorbers other than the dissolved organic matter (DOM). Spectral absorbance of the fliltered samples were acquired at Wallops, Cornell Laboratory for Environmental Remote Sensings (CLEARS), and Woods Hole Oceanographic Institute. Spectral Fluorescence were also collected at CLEARS (Dr. Tony Vodacek, as mentioned previously, is now a NRC Resident Research Associate at Wallops) and WHOI (Dr. Niel Blough).

Recovery of the absorption coefficients for the light-absorbing or chromophoric components of the dissolved organic matter (aCDOM) from their fluorescence emission has been investigated by laboratory analyses of the surface samples gathered from the Feb. 28, 1991 cruise. These absorbance and fluorescence analyses, (and our own efforts on samples obtained from previously reported TAMBEX II work in Tampa Bay and

JGOFS/Monterey Bay), show that absorption coefficients in the near ultraviolet can be directly retrieved from measurements of the fluorescence emission of CDOM. Thus, absorption coefficients in the visible can potentially be obtained from the empirical observation that CDOM absorption is exponentially related to wavelength. The errors in the laboratory fluorescence measurements was minimized through the combined use of the water Raman scatter as an internal radiometric standard and quinine sulfate as a reference. Thus, the aCDOM algorithm retrieval errors are primarily attributable to the use of commercial spectrophotometers having maximum optical path lengths of 10 cm. Use of emerging technologies, such as the long-path reflecting tube absorption meter and the integrating cavity absorption meter, are suggested for future improvements to aCDOM retrieval algorithms. While the aCDOM retrieval appears feasible, the relationship to CDOM emission is susceptible to changes in fluorescence yield, so the continued temporal study of marine samples from many diverse oceanic locations is needed. When applied to shipboard and aircraft laser fluorometers, this retrieval methodology and the resulting DOM absorption coefficients will be used ocean color models and associated satellite sensor/algorithm developments directly aimed at phycoerythrin retrieval. The DOM is important since it is a major interferant to the detection and quantification of chlorophyll and chlorophyll accessory pigmants (CAP) such as phycoerythrin. A manuscript titled: "Inherent Optical Properties of the Ocean: Retrieval of the Absorption Coefficient of Chromophoric Dissolved Organic Matter from Fluorescence Measurements is now 'in-press' based on the fluorescence/absorption work.

III. Other Planned Algorithm Activities

Plans are in progress to participate with the Airborne Oceanographic Lidar in Dr. Neil Blough's cruise of the Research Vessel Cape Henlopen in the MODIS Test Site in August 1993. (Dr. Blough is from Wood's Hole Oceanographic Institution and is an EOS Interdisciplinary Science Co-investigator with Dr. Peter Brewer on the Biogeochemical Fluxes at the Ocean/Atmosphere Interface project). To assist our MODIS investigation to directly address the quantification of the DOM signal, Dr. Blough will provide along track DOM fluorescence and filtered surface water samples.

Ocean color modeling efforts continue in an attempt to recover the pigment within the presently designated MODIS bands. Phycoerythrin has never been reported to be detectable in the MODIS bands but efforts are centered on the absorption bands at 495nm and 545nm. These phycoerythrin absorption bands occur sufficiently close to MODIS (and

SeaWiFS) bands that the use of models may allow their retrieval. However, the chlorophyll, DOM and non-absorbing backscatter must first be adequately recovered, otherwise the phycoerythrin pigment will be obscured.